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7553-5 AND 7553-6 TYPE K-3 UNIVERSAL POTENTIOMETERS

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7553-5 AND 7553-6 TYPE K-3

UNIVERSAL POTENTIOMETERS

SPECIFICATIONS

MEASURING RANGES

1.6 (High) Range: 0 to 1.6110 volt
.16 (Med.) Range: 0 to 0.16110 volt
.016 (Low) Range: 0 to 0.016110 volt

LIMITS OF ERROR

For both measuring and standardizing. Values include effect of residual thermal emfs at 90% relative humidity.

With Normal Standardizing*

1.6 (High) Range: ±(0.01% of reading + 20 μv)
.16 (Med.) Range: ±(0.015% of reading + 2 μv)
.016 (Low) Range: ±(0.015% of reading + .5 μv)

With Alternative Standardizing Procedure*

1.6 (High) Range: ±(0.005% of reading + 20 μv)
.16 (Med.) Range: ±(0.01% of reading + 2 μv)
.016 (Low) Range: ±(0.01% of reading + .5 μv)

THERMAL EMFS

On operation of switches: less than 0.1 μv (of very short duration).
On operation of slidewire: not more than 0.3 μv (of very short duration).

GALVANOMETER DAMPING

Provision is made for selection of one of four galvanometer damping resistances contained in the potentiometer. These resistances are approximately 100, 400, 2000, and 10,000 ohms and provide adequate damping over entire range of 50 to 20,000 ohms CDRX.

GALVANOMETER SENSITIVITY

Selection is provided, by means of tap keys, to obtain sensitivities of approximately 1/400 (LOW key), 1/20 (MED key), and 1 (HIGH key) times the sensitivity of the galvanometer used.

INTERNAL RESISTANCE

Resistance of potentiometer as seen from source of unknown emf varies from approximately 180 ohms at highest voltage setting to approximately 110 ohms at zero voltage setting.

AUXILIARY EMF RANGES

1.6 (High) Range: 0 to 1.5 volts in steps of 0.1 volt
.16 (Med.) Range: 0 to 0.15 volts in steps of 0.01 volt
.016 (Low) Range: 0 to 0.015 volts in steps of 0.001 volt

SUPPLY BATTERY CURRENT DRAIN

24.4444 ma (Final digit recurs indefinitely.)

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*The two methods of standardizing the potentiometer current are described under Operation, Part II.

PART I

GENERAL INFORMATION

1. DESCRIPTION

The 7553-5 and 7553-6 Type K-3 Universal Potentiometers are precision, guarded instruments designed for highly accurate measurements of emfs. The 7553-5 Potentiometer is arranged for use on a table or bench, and the 7553-6 for panel or rack mounting. Except for the instrument cases, both potentiometers are identical with the basic technical data listed under Specifications.

For mounting dimensions of the 7553-6, refer to Fig. 12. The instrument is mounted in place on a rack or panel by means of four (4) screws (one near each corner of the top plate) and it is held in place in the case by the screws which hold the handles in place (two screws in each handle). The removable cover (see Fig. 12) is held in place by the four cover fasteners as indicated.

The source of unknown emf is connected to binding posts EMF (– and +). The EMF– binding post is connected internally to the GRD binding post which is connected to the metal case of the instrument. Separate GALVANOMETER binding posts (0, 100, 400, 2000, and 10,000) are provided for the values of damping resistance indicated at these posts, with post 0 serving as a common point. Binding posts SC (– and +) and BATTERY (–, +2.6V, and +3.3V) are for connecting the external standard cell and external battery respectively. The AUX EMF (– and +) binding posts are useful for special applications described later.

Potentiometer balance is obtained by means of knobs A, B, C, and C' grouped around the center of the top plate. The voltage measurement is indicated as a direct digital reading at the central reading window. The knob marked RANGE controls a three position switch providing the basic range when in the 1.6 position. The other positions of the range switch provide ranges one-tenth (.16) and one-hundredth (.016) of the basic range. The decimal point in the digital reading is properly positioned by mechanical means when the RANGE knob is rotated to the appropriate position. Knobs A and B control 15 step and 10 step switches respectively, each advance of the switch simultaneously raising the corresponding digit in the reading. Knob C controls a slidewire having scale markings to be read "in line" with the digital reading. Knob C' provides a slow motion control of this slidewire for final precise balance adjustment. Procedure for operating the dials to obtain balance and making readings is covered in Section 7.

The two dials on the left side of the potentiometer are associated with the five binding posts above these dials. The dial marked AUX POT provides means for applying various values of emf, up to 1.5 volts, at the AUX EMF binding posts for comparison purposes in applications requiring a check of the stability of a second emf. The three ranges (0 to 1.5 volts, 0 to 0.15 volt, and 0.015 volt) of auxiliary emf are determined by the position of the RANGE knob. The six position function switch below the AUX POT dial permits selecting either positive or negative polarity unknown potentials by reversing the polarity of

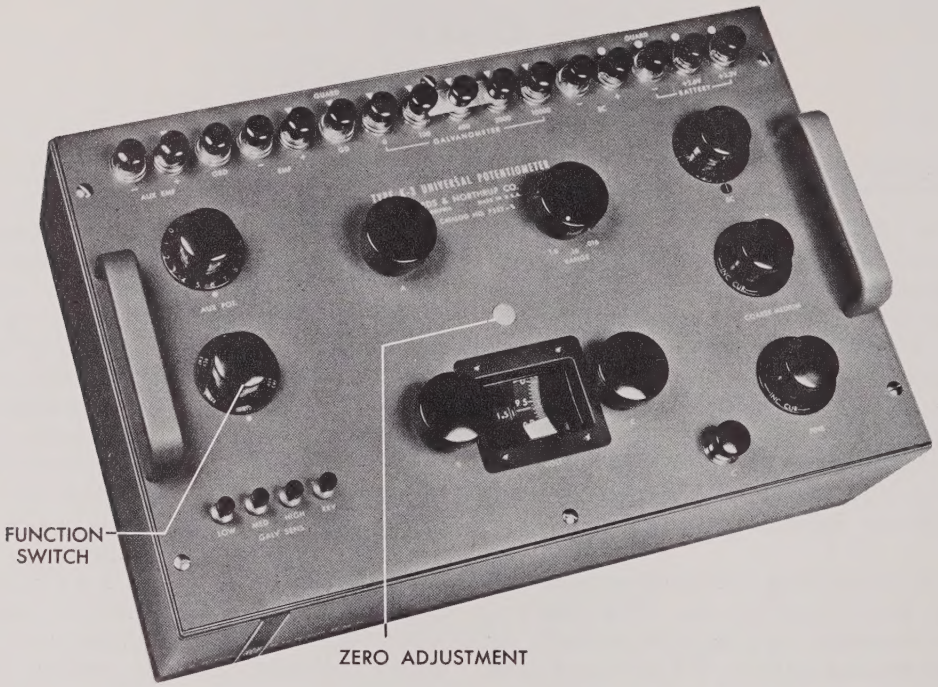


Fig. 1—7553-5 Type K-3 Universal Potentiometer.

the potentiometer with respect to the unknown emf and the galvanometer circuit when the dial is turned from EMF to REV EMF. This switch is turned to either of the STD positions for the standardizing operation. When the function switch is in the AUX EMF position it places the galvanometer circuit in the AUX EMF circuit. The CHECK position is useful in certifying the instrument.

The three dials on the right side of the potentiometer are associated with the five binding posts above these dials. The calibrated standard cell dial, marked SC, is provided for adjusting the standardizing circuit reference voltage to the voltage of the standard cell being used. The FINE dial controls a slidewire and the COARSE-MEDIUM dial controls a slidewire and a 15 step switch which serve to vary the total potentiometer current when standardizing. The latter slidewire and switch are controlled in a tandem arrangement. The slidewire is adjustable through one full turn of the COARSE-MEDIUM dial and further rotation at either limit operates the switch. Binding posts BATTERY (– and +3.3V) should be used for connecting the bridge supply voltage when two alkaline type cells or dry cells, in series, are used, while binding posts BATTERY (– and +2.6V) should be used when a lead cell is used for this purpose. The positions of the FINE and COARSE-MEDIUM dials, relative to their positions when the cells are charged, will provide an approximate indication of the remaining life of these (working) cells.

The keys marked GALV SENS are used to close the null detector circuit for three different galvanometer sensitivities. The highest sensitivity is

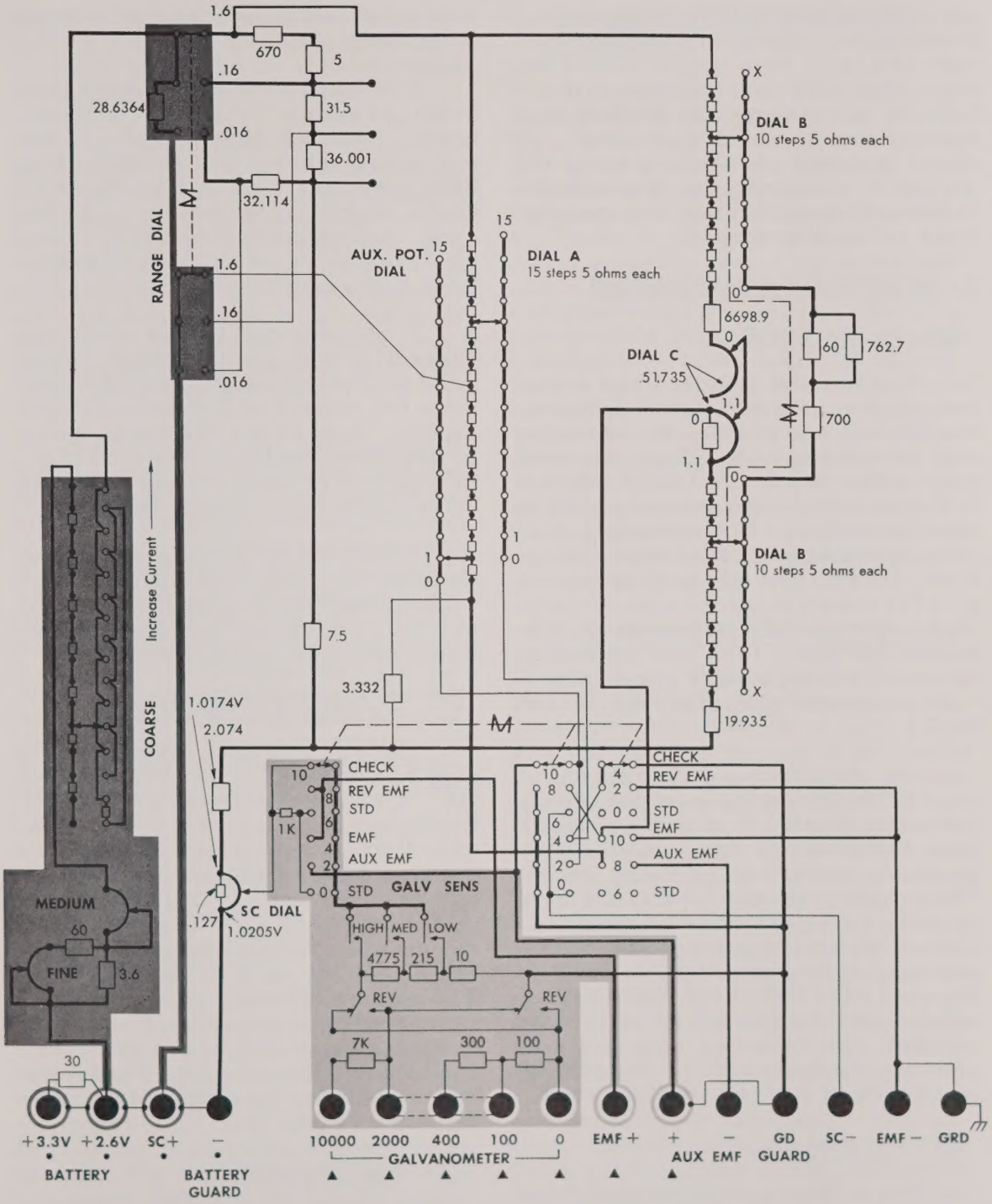


Fig. 2—7553-5 or 7553-6 Type K-3 Potentiometer schematic circuit diagram. Shaded areas indicate guarding.

selected by key HIGH which can be locked down, to keep the detector circuit closed, by a slight turn of the key. The REV key functions, in effect, to interchange the binding post connections of the null detector. It offers a means of obtaining twice the available sensitivity of the null detector and compensation for spurious emfs in the detector.

2. ACCESSORY COMPONENTS

2A. Standard Cell

Two forms of standard cell satisfactory for use with the K-3 Potentiometer are available; the saturated and the unsaturated. The saturated cell is the more precise of the two. It has an emf of approximately 1.01864 absolute volts at 20 C, which is constant over long periods of time. However, its relatively high temperature coefficient requires special care, such as the use of a temperature controlled oil bath. (The emf decreases by about 40 microvolts per degree C rise in temperature between 10 and 40 C.)

The unsaturated cell is the commercial form usually used for potentiometric work. It is more portable than the saturated type, and its temperature coefficient is much lower. When new, its emf is about 1.0190 absolute volts. This tends to decrease about 100 microvolts (0.01%) per year, giving a useful life of about ten years. The L&N 7308 Eppley unsaturated Standard Cell is recommended. Its internal resistance is not over 500 ohms and its emf at 20 C is 1.01884 to 1.01964 absolute volts.

2B. Working Cells

The source of working current used must provide a current drain through the potentiometer of 24.44 milliamps and a voltage of at least 1.8 volts.

The L&N 7597 lead storage cell, having a rating of 2 volts, 200 ampere-hours, is recommended. This cell has low self-discharge and resultant long life, providing about four-thousand hours uninterrupted service. In this case, binding posts BATTERY (– and +2.6V) must be used for the connections to the potentiometer.

If two dry cells are used, the current in the potentiometer circuit must be adjusted at frequent intervals since the voltage of dry cells changes rapidly, even at low discharge rates. In this case, binding posts BATTERY (– and +3.3V) must be used for the connections to the potentiometer.

The COARSE rheostat on the potentiometer covers the 1.8 to 2.2 volt range of the lead cell and also the 2.6 to 3.3 volt range of two Edison (alkaline type) cells or No. 6 dry cells.

2C. Constant Voltage Supply

The source of working current may be from a Constant Voltage Supply. Available from the Leeds & Northrup Company is the 099034 Constant Voltage Supply which provides a current of 24.44 milliamps and a voltage of three volts. Operating from line voltage, the 099034 provides a constant d-c voltage for the measuring circuit of the K-3 potentiometer. The normal 117 volt, 60 cycle supply is reduced by a step-down transformer and is converted to d-c by rectification with silicon diodes. The voltage is regulated by a two stage Zener diode network.

2D. Null Detector

The null detector used must be selected according to the precision

desired and the type of measurement being made. This detector may be an electronic type or a conventional d-c moving-coil galvanometer.

If an electronic type detector is preferred, the L&N 9834 Electronic D-C Null Detector is recommended. This detector has a maximum sensitivity, at source resistances up to 1000 ohms, of ±0.2 microvolt per division; and at a source resistance of 100,000 ohms, of ±0.9 microvolt per division. The period is less than 2 seconds and it operates on a 120 volt, 50/60 cycle line voltage.

The choice of a galvanometer is based upon the sensitivity, critical damping resistance, and period desired. The external critical damping resistances provided in the potentiometer offer adequate damping over the entire range of 50 ohms to 20,000 ohms galvanometer CDRX. Where highest precision is required, either a very sensitive reflecting type galvanometer with an all-copper circuit, such as the L&N 2430 Series Type E Galvanometers, or an electronic null detector, such as the L&N 9834 Electronic D-C Null Detector, should be used.

Refer to Fig. 11 when selecting a galvanometer.

2E. Guarded Leads

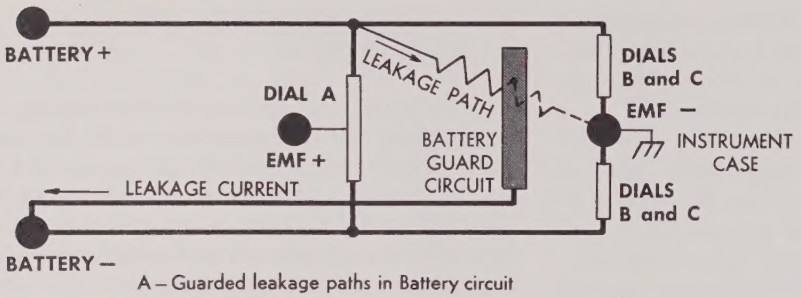
The guarded leads, referred to in these directions, connect only one side of an external circuit to the potentiometer. This lead may be either twin-lead cable or coaxial cable. It is extremely important that both conductors be highly insulated from ground. The resistance of the outside insulation (between the guard conductor and ground) must be not less than 500 megohms.

3. THEORY OF GUARDING AND SHIELDING

It is essential that the term guarding should not be confused with shielding. Shielding, which is normally grounded, provides freedom from electrostatic effects, particularly in dry atmospheres. The metal case and top plate of the potentiometer, normally grounded, serve as an electrostatic shield. Guarding, however, refers to the use of special circuitry, insulated from ground, to provide freedom from adverse effects of leakage current paths between critical circuit points. The battery and galvanometer circuits in the potentiometer are individually guarded as described below. The solid circles and triangles on the top plate identify the binding posts of circuits which are guarded and for which external guarding may be desirable.

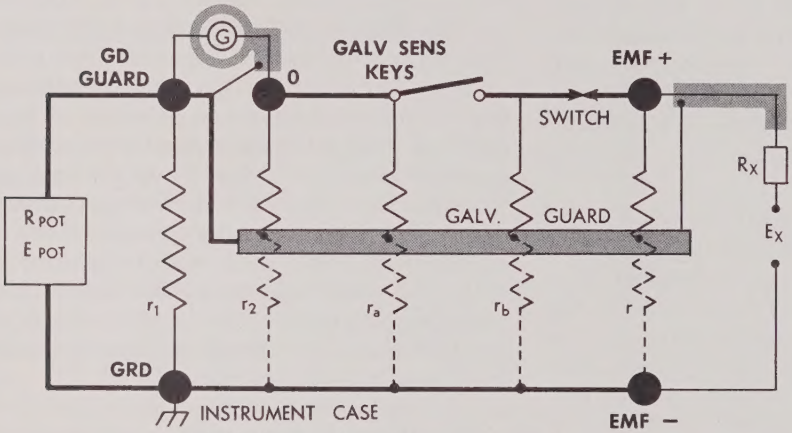
3A. Battery Circuit Guard System

The battery guard prevents errors resulting from leakage currents, between the BATTERY+ circuit and ground, passing through a portion of the measuring circuit when the instrument is used under conditions of high humidity. Fig. 3, part A, illustrates the leakage paths which could exist without guarding, and how guarding eliminates their effect. These paths exist from the BATTERY+ binding posts, and their associated circuit components, to the case of the instrument and back to BATTERY – through part of the C slidewire and B decade branch. As illustrated, the battery guard intercepts these leakage currents flowing to the case by providing a low resistance path back to the battery. This prevents the currents from flowing through part of the C slidewire and B decade branch, which would introduce a spurious voltage drop in this low potential part of the circuit.



A – Guarded leakage paths in Battery circuit

The battery guard intercepts leakage currents between high potential points and the instrument case. These leakage currents would cause errors if permitted to flow back to **BATTERY**— through the low potential parts of the measuring circuit, **B** and **C.**



B – Guarded leakage paths in Galvanometer circuit

The galvanometer guard intercepts leakage currents to the instrument case from the **EMF+** terminal and all associated circuits including the galvanometer terminals, sensitivity keys, std. – emf switch, etc. If these leakage currents were permitted to flow to the case, the battery potential would pass them directly through the galvanometer, causing zero offset. The guard also terminates leakage paths r and r_b which, if they existed, could introduce measuring errors by excessive shunting of high impedance sources.

Fig. 3—7553-5 or 7553-6 Type K-3 Potentiometer guarding features.

The shaded guard shown in Fig. 3, part A, is a theoretical representation of the insulated conductors surrounding the leads and circuit components identified in Fig. 2 by the same tone shading. Binding posts BATTERY– is connected to this guard. The associated binding posts, the guards of which are also connected to BATTERY–, are identified on the instrument by a solid circle ●.

It is evident that for best performance in humid atmospheres leakage to ground from externa circuits connected to these binding posts should be avoided by the use of external insulated guarding as described in sections where this is required.

3B. Galvanometer and EMF Circuit Guard

The galvanometer guard prevents an unstable galvanometer zero. This instability would result from leakage currents to ground passing through the galvanometer. Fig. 3, part B, illustrates the manner by which the leakage paths are terminated on the guard conductor, in effect eliminating the paths to the case represented by the broken lines. Except when the potentiometer reads zero, a potential exists between GD, GUARD and the case. If the leakage paths to the case represented by r_2 and r_a were permitted to exist, this potential would cause leakage currents to pass through the galvanometer, even when the tap keys are open. Since the magnitude of this

current varies with the insulation resistance and the potential, (which varies with dial settings), an unstable zero would result.

The guard system in effect, eliminates these leakage paths by surrounding the entire galvanometer circuit in the potentiometer with an equipotential surface; i.e., the surfaces between which the leakage paths are most likely to exist are now at essentially the same potential. The only remaining leakage path to ground is r_1, which exists between the case and the guard. This leakage path has negligible adverse effect because it exists across the entire potentiometer circuit which is of low resistance.

The shaded guard shown in Fig. 3, part B, is a theoretical representation of the insulated conductors surrounding the leads and circuit components identified in Fig. 2 by the same tone shading. The binding post to which these conductors are connected, is marked GD, GUARD on the top plate. The associated binding posts, the guards of which are also connected to GD, are identified by a solid triangle ▲.

The same guard system prevents errors resulting from excessive shunting of high impedance sources. Leakage resistances such as r_b and r, which are associated with the binding post and the lead for the ungrounded side of the unknown emf source, would, if not eliminated by the guard system, introduce an error because of their voltage divider effect when R_x, Fig. 3, part B, is high.

It is evident that for best performance, leakage to ground from the galvanometer and its leads and from the +EMF external lead (when the unknown emf has high internal impedance) should be avoided by the use of external insulated guarding as described in sections where this is required.

3C. Electrostatic Shielding

Disturbances caused by electrostatic charges which may accumulate on the operator's body in dry atmospheres are avoided by using the metal case and top plate as a grounded shield. This shield intercepts and carries to ground all electrostatic charges which might otherwise pass through the potentiometer circuit and the galvanometer. Every knob and key handled by the operator is shielded in this manner.

4. PREPARATION FOR USE

4A. Working Cells

If a lead storage cell is used, connect it leads to the +2.6V and -BATTERY binding posts. If alkaline or dry cells are used, connect two cells in series across the +3.3V and -BATTERY binding posts. Place the cell or cells where they will be protected against large or sudden temperature changes as these sources have appreciable temperature coefficients of emf.

The design of the K-3 Potentiometer includes guarding to reduce battery to ground leakage current effects which could otherwise be significant, particularly under conditions of high humidity. For maximum effectiveness, this guarding should be extended outside the potentiometer to the source of working current. To provide this external guarding, mount the cell on a metal plate and place this metal plate on a sheet of insulating material such as polystyrene, methyl methacrylate, vinyl or epoxy. Use an individual guarded lead from the positive cell terminal to the potentiometer, connecting the guard to the metal plate at

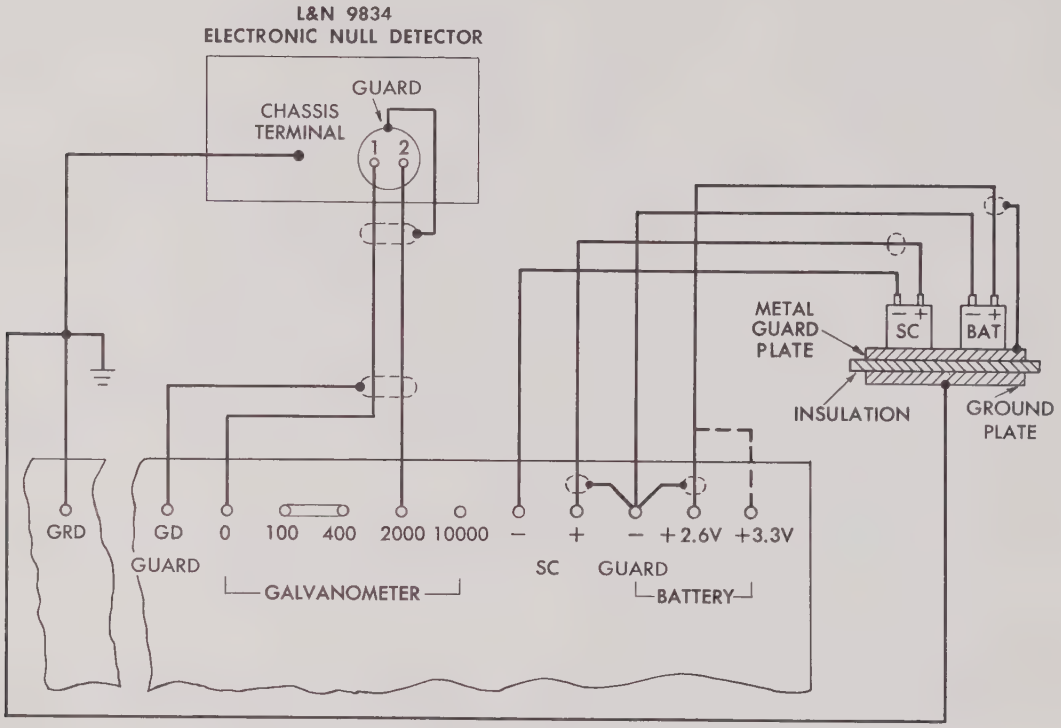


Fig. 4—Connections for working and standard cells.

the cell end and to the —BATTERY binding post on the potentiometer as shown in Fig. 4. Note that the —BATTERY binding post is insulated from the case and ground. The guarded lead, including the guard itself, must be completely insulated from ground.

4B. Constant Voltage Supply

If an 099034 Constant Voltage Supply is used, Directions 177255 supplied with the 099034 should be followed. Specifications are listed. Installation and operation of the 099034 are described and explained.

4C. Standard Cell

For the normal, internal method of standardizing, connect the standard cell terminals to binding posts SC on the potentiometer and set the SC dial to the voltage of the standard cell as indicated on the certificate or tag furnished with the cell. When this setting is made, the potentiometer readings will be in terms of the unit system indicated on the standard cell certificate or tag. Because the emf of an unsaturated type standard cell decreases approximately 0.01% per year, it is suggested the cell be checked at least once a year and the SC dial set to the exact emf measured. CAUTION: Except for the check and adjustment just described, the SC dial should not be disturbed after it is set at the proper voltage value for a specific standard cell.

If the alternative method of standardizing is to be used, (in order to obtain the reduced limits of error

listed in the Specifications) connect the terminals of the standard cell to the EMF binding posts and set the potentiometer dials for a reading equal to the voltage of the standard cell used. The procedure is given in Section 5.

An unsaturated standard cell should be placed where ambient temperatures will remain between −4 C and +40 C if the cell is to remain within ±0.01% of its certified value. Operation at temperatures approaching these limits is not recommended.

To obtain maximum guarding against leakage currents, mount the standard cell in the same manner as the working cell(s) described in Section 4A. Use an individual guarded lead from the positive cell terminal to the potentiometer, connecting the guard at the potentiometer end to the −BATTERY binding post on the potentiometer as shown in Fig. 4.

4D. Galvanometer

Connect the galvanometer between the 0 binding post and one of the other four GALVANOMETER posts provided, selecting the post marked with a damping resistance value corresponding approximately to the external critical damping resistance (CDRX) specified for the galvanometer used. If the L&N 9834 Null Detector is used, connect it between binding posts 0 and 2000. IMPORTANT: Remove the link between posts 400 and 2000 when using posts 2000 and 10,000. The resistance values marked are nominal. The polarity of the galvanometer connection is significant only if the user desires the direction of deflection to indicate that the potentiometer reading is above or below the balance point. If the REV key is not depressed, the 0 post is connected internally to the +EMF binding post.

NOTE: If an electronic null detector, other than the L&N 9834, is used, connect the side of the detector which is most highly insulated from the chassis to the 0 post on the potentiometer and do not use the REV key. This precaution will avoid leakage currents to ground through the detector from a critical portion of the potentiometer when the potentiometer case is grounded. Obviously, a measurement is not possible if the potentiometer case and one side of the detector are both connected directly to ground. However, the detector may be grounded through a 0.01 to .1 microfarad mica capacitor (or other type having equivalent insulation resistance). See Section 16 for special connections when making electrochemical measurements.

The entire galvanometer circuit in the potentiometer is guarded against instability of galvanometer zero caused by leakage currents from the galvanometer binding posts and all associated circuits to ground. This guarding should be extended externally to the galvanometer itself. To do so, place the galvanometer on a metal plate which is insulated from ground as described for the working cells in Section 4A. Use individual guarded leads for the connections to the GALVANOMETER binding posts on the potentiometer, connecting the guard of each lead to the metal plate at the galvanometer end and to binding post GD, GUARD at the potentiometer end.

4E. Source of Unknown Emf

Connect the unknown emf (less than 1.6 volts) between the binding posts EMF (− and +), observing polarity. Where the impedance of the source of unknown emf is relatively high (see Section 16 for electrochemical measurements) it is desir-

able to extend the galvanometer guard circuit, provided in the potentiometer, to the source of unknown emf by using a guarded lead for the EMF+ binding post connection. Connect the guard to binding post GD, GUARD. It should be noted that the negative side of the unknown emf is connected to the metal top plate on the potentiometer which, in turn, is normally grounded.

For voltage measurements greater than 1.6 volts, and for current measurements, instrument calibration, and other special applications, refer to Part III.

4F. Auxiliary Potentiometer Connections

The voltages available at the AUX EMF binding posts are useful whenever a stable reference emf is desired. Although not continuously variable, there are fifteen (15) different values for each of the three ranges. The fifteen values are obtained by the position of the AUX POT switch. The auxiliary emf circuit can be used as an auxiliary potentiometer to supply a stable emf for test purposes. The same null detector is used in both the AUX EMF circuit and the EMF circuit; the switching from one circuit to the other being accomplished by the position of the function switch, Fig. 1. General wiring connections for such an arrangement are shown in Fig. 8. This arrangement is adaptable to any particular application involving a quantity to be monitored periodically for comparison against the auxiliary emf. Both the measured and monitored quantities may be directly connected emf sources or a volt box or current shunt connection.

In applications where the source impedance of the measured or monitored quantity is high, it is desirable to guard against leakage currents to ground from all leads and components connected to the +EMF binding post. In these cases, use guarded leads between +EMF binding post and the measured or monitored emf sources.

When measuring with an auxiliary emf connected, a common mode voltage of up to 1 volt is permissible providing the source resistance is less than 1000 ohms. If the voltage or source resistance exceed these values, a test should be made to determine what the effect will be. To do this, connect and then disconnect the lead from the +AUX EMF binding post and see if the emf reading is disturbed. If the reading is disturbed, a special high resistance switch should be used in the external auxiliary emf circuit.

4G. Grounding

The metal case and top plate of the potentiometer, when grounded, form a shield against electrostatic disturbances by the operators body when the instrument is used in very dry atmospheres. To provide this protection, connect binding post GRD to an earth ground. Note that when this is done, the negative side of the unknown emf is also grounded through binding post EMF−. For applications where it is not desirable to ground the negative side of the source of unknown emf, connect the GRD binding post in series with a 0.01 microfarad mica capacitor (or equivalent) connected to earth ground.

CAUTION: If the unknown emf or monitored quantity are electrically related to line-operated apparatus or any high level voltage source, it is important that the GRD terminal be connected directly and securely to a good earth ground. This safety precaution will avoid the risk of high voltage between case and ground and the resulting hazard to the operator.

PART II

OPERATION

5. CURRENT STANDARDIZATION

For normal internal standardizing, set the SC dial at the value corresponding to the voltage indicated on the certificate or tag furnished with the standard cell and turn the function switch to either of the STD positions.

NOTE: The COARSE-MEDIUM dial operates a 15-step switch for the coarse adjustment and a slidewire for the medium adjustment, on the same shaft. As this dial is turned in the INC. CUR. direction, the slidewire reaches its limit. A slight further turn, in the same direction, advances the coarse adjustment switch to the next position. The range of the medium adjustment slidewire is slightly greater than one step on the coarse adjustment switch. This permits the medium adjustment slidewire to be turned in the counterclockwise direction to obtain an approximate balance. The FINE dial operates a slidewire for obtaining the final balance.

Depress the GALV SENS LOW key momentarily and observe the null detector for any deflection. If it does not balance at zero, adjust the COARSE-MEDIUM dial until there is very little or no deflection of the null detector when key LOW is depressed or released. Then depress the GALV SENS MED key momentarily and again observe the null detector for any deflection. If it does not balance at zero, again adjust the COARSE-MEDIUM dial until there is very little or no deflection of the null detector when key MED is depressed or released. Now depress the GALV SENS HIGH key (this key may be locked down by turning it approximately 90° in either direction) and again note the null detector for any deflection. If it does not balance at zero, adjust the FINE dial until the null detector balances at zero when the HIGH key is depressed or released. Then release the HIGH key. The current is now standardized.

Be sure to turn the selector dial back to EMF as soon as the standardizing adjustment has been completed. Subsequent adjustments may require only readjustment of the FINE dial. When this dial has been rotated to its clockwise limit, advance the COARSE-MEDIUM dial in a clockwise direction (a slight amount or one step, if near the limit of the MEDIUM slidewire) and readjust the FINE dial to obtain a balance.

To use the alternative standardizing procedure, which provides reduced limits of error, set the potentiometer dials for a reading corresponding to the voltage indicated on the certificate or tag furnished with the standard cell and turn the function switch to EMF. With standard cell connected across the EMF posts, proceed to adjust the coarse-medium and fine dials, as described above, until a precise balance is obtained. Then transfer the standard cell connection to the SC binding posts and turn the function switch to STD. Now adjust the SC dial until a precise balance is obtained. Turn back to EMF.

A lead storage cell must be renewed or recharged when the COARSE-MEDIUM dial has been turned to its clockwise limit (cell voltage of approximately 1.8 volts). If dry cells or alkaline type cells are used, they

TABLE I - USE OF RANGE SWITCH TO OBTAIN READINGS OF HIGHEST POSSIBLE ACCURACY

	VOLT(S)		VOLT		RANGE
emf between	0 (zero)	and	0.016110	use	0.016
" "	0.016110	"	0.16110	"	0.16
" "	0.16110	"	1.6110	"	1.6

should be renewed or recharged when their voltage reaches approximately 2.2 volts, as indicated by excessive drift and the need for frequent re-standardizing.

During a series of measurements, it is desirable to check the potentiometer current occasionally and adjust it, when necessary, in accordance with the above standardizing procedure. The frequency with which such checks are required depends upon the condition of the working cells and the precision required in the measurements. Do not disturb the settings of the FINE or COARSE-MEDIUM dials until the next standardization.

6. ZERO ADJUSTMENT

A divided circuit potentiometer, such as the K-3, requires a zero adjustment to compensate for long-time changes of circuit balance. The adjustment consists of simply rotating the entire slidewire molding, contact, arm and scale. This adjustment changes the scale reading without disturbing slidewire to contact relationship.

Connect EMF binding posts — and + together with a short copper wire.

Connect the galvanometer or null detector and a 1-1/2 volt dry cell, or other working cells, to the proper binding posts.

Turn the RANGE switch to 1.6, knob A to zero, knob B to zero and knob C counterclockwise to the 00 position.

Turn the function switch, Fig. 1, to EMF and balance the potentiometer (null detector balanced at zero) by adjusting knobs C and C'. The reading at the window should be 0.0000.

If the 00 line on the scale for knob C is not now precisely under the hairline of the window, make the adjustment outlined below.

Remove the zero adjust cap, Fig.1, to expose the adjusting screw through the hole in the top plate.

Use a screwdriver and carefully adjust this exposed screw to bring the zero line on the scale for knob C precisely under the hairline of the window.

Replace zero adjust cap, Fig. 1.

7. MEASURING PROCEDURE

Always standardize the potentiometer before use, as described in Section 5.

If the magnitude of the emf is known to be greater than 1.611 volts, refer to Section 8.

If the approximate magnitude of the emf is known, one of the three ranges can be selected accordingly by means of the RANGE knob. (See Table I.) The range will be indicated by the position of the decimal point in the digital reading. If the polarity of the

emf is known to be reversed, set the selector dial on REV EMF.

If the polarity and approximate value of emf is unknown, rotate the RANGE knob clockwise to the highest range and set the selector dial on EMF. Then proceed to obtain balance as described below.

7A. Preliminary Balance

To obtain balance, first rotate knobs A, B, and C to their zero positions. Then turn knob A clockwise over its range of fifteen steps, tapping GA SENS key LOW after each step, until the deflection of the null indicator reverses. Then rotate A back one step and repeat the same procedure using knobs B and C in succession. When a reversal of deflection is obtained with knob B, turn this knob back one step and proceed to obtain final balance with knobs C and C'. The reduction-drive vernier action of knob C' permits precise balance adjustment.

If a reversal of null deflection has not occurred when all knobs have been rotated over their full ranges, set the selector dial on REV EMF. Then repeat the above procedure.

It will be evident in some cases, if the approximate emf was unknown and the highest range used, that a more accurate measurement can be made on a lower range. Adjust the knobs accordingly until the emf is indicated to the most significant figures possible and then make final balance with knobs C and C'.

7B. Final Balance

When making final balance adjustments, adjust knob C to an approximate balance point, tapping GALV SENS key LOW after each small adjustment of C until only a very small deflection of the null indicator results. In the same manner, tap key MED and adjust knob C. Then adjust knob C' to obtain a final precise balance, tapping key HIGH after each small adjustment until there is no deflection of the null indicator.

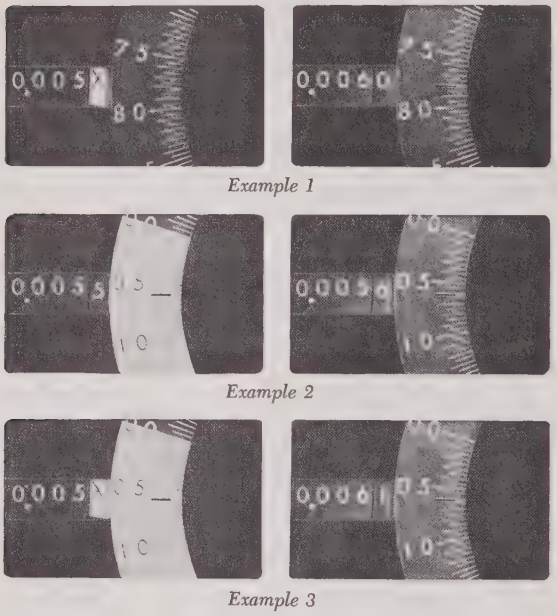
Note the reading obtained. Lock down key HIGH by turning it slightly. Then depress key REV and adjust knob C' until there is no deflection of the null indicator. Release key HIGH, and note the new reading. A difference in the two readings indicates the presence of a thermal emf in the detector circuit. The true reading is the average of the two readings noted. This use of the REV (reverse) key serves to eliminate the effect of thermal emfs in the detector circuit.

7C. Making a Reading

The value of the measured emf, in volts, appears directly in the central reading window with decimal point properly placed.

The digital figure controlled by knob B can be advanced one step above 9, in which case an X appears in the reading. To interpret such a reading consider that the X represents zero and numerically increase the preceding digit by one. This is illustrated by Example 1 in Fig. 5 where 0.005X78 is read 0.006078. If the user so desired, a direct reading of the emf value can be obtained by merely rotating knobs A and B one step clockwise, except where the significant figures are 15X, indicating the end of that particular range.

The slidewire can be rotated beyond 100 by an overtravel of 10 percent, in which case the overlap slidewire scale markings, from 0 to 10, appear on a white background to distinguish them from the remainder of



Example 1

Example 2

Example 3

Fig. 5—Sample readings to illustrate overlap of dial ranges. Each example shows equivalent dial settings.

the scale values. To read such an emf, use the slidewire scale reading in the usual manner and numerically increase the preceding digit (associated with dial B) by one. This is illustrated by Example 2 in Fig. 5 where 0.005506 is read 0.005606.

Example 3 illustrates the case where both of the above conditions have occurred simultaneously. The X, considered as a zero, is increased by a single step to become a one. Thus, 0.005X06 is read 0.006106 in Example 3.

PART III

OTHER APPLICATIONS

8. EMF MEASUREMENTS BEYOND POTENTIOMETER RANGE

It is necessary to use a volt box for measurements of emf values beyond the highest range of the potentiometer (greater than ±1.611 volts). When using a volt box, the unknown emf is connected across a series of precision resistors and a definite known fraction of the total unknown emf is applied to the potentiometer. The unknown emf is evaluated by multiplying the potentiometer reading by the volt box factor for the point to which the unknown is connected. Fig. 6 illustrates the use of one type of volt box, L&N 7582 or 7592 which are 750 ohms-per-volt each. It is important to note that, when measuring voltages with a volt box, current is drawn from this source of unknown emf.

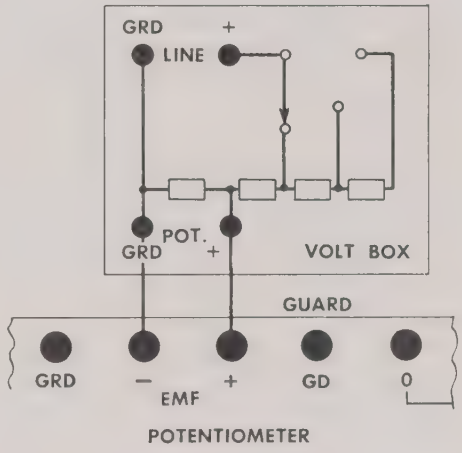


Fig. 6—Connections for using a volt box with the 7553-5 or 7553-6 Potentiometer.

Connect the grounded side of the unknown emf to the GRD post marked LINE on the volt box and the other side to the LINE binding post marked for a maximum voltage greater than the emf to be measured. The L&N 7582 or 7592 volt boxes utilize a selector switch for this purpose as shown in Fig. 6.

CAUTION: When using a volt box in conjunction with a current shunt, where the shunt is on the load side of the volt box, the voltage reading must be corrected for the voltage drop across the shunt.

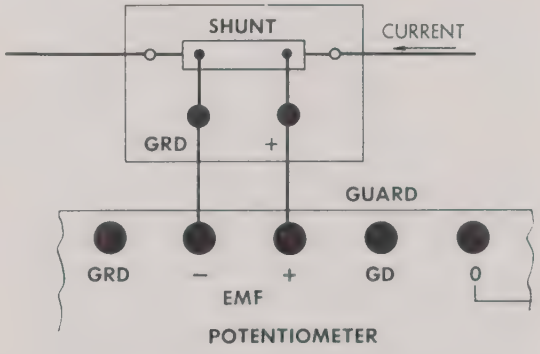


Fig. 7—Connections for using the 7553-5 or 7553-6 Potentiometer for making current measurements.

9. CURRENT MEASUREMENTS

Current values are determined with the potentiometer by measuring the voltage drop across a known resistor as shown in Fig. 7. It is necessary to use a standard resistor or shunt having a current rating at least as great as the highest current to be measured. The L&N 4385 Shunt is suggested for this purpose.

It is necessary to multiply the potentiometer reading by the reciprocal

of the shunt resistance (marked on the top plate of the L&N 4385 Shunt Box) to obtain the current reading in amperes.

Connect the potential posts on the shunt to the potentiometer as shown in Fig. 7. Then obtain the emf reading in the usual manner, described in Section 7, and divide this by the shunt resistance.

CAUTION: When using a current shunt in conjunction with a volt box, where the volt box is on the load side of the shunt, the current reading must be corrected for the current passing through the volt box.

10. CALIBRATION OF POTENTIOMETER MEASURING INSTRUMENTS

The K-3 potentiometer is often used as a reference standard when calibrating potentiometer type emf measuring instruments. The K-3 potentiometer is adjusted to read the various emf values at which it is desired to check the recorder or indicator calibration. If binding posts GD and EMF – are connected to the + and – terminals respectively on the recorder or indicator, the emf value appearing in the window is applied directly to the instrument and the galvanometer is not connected into the circuit. This eliminates the necessity of shorting out the galvanometer. When the function switch is set on STD, the galvanometer is automatically connected into the standardizing circuit; therefore, the potentiometer may be standardized at any time without wiring changes. The polarity of the emf may be reversed at any time by merely rotating the function switch to REV EMF.

11. CALIBRATION OF D-C VOLTMETERS

To use the potentiometer for d-c voltmeter calibration, connect the appropriate line terminals of a volt box across the voltmeter terminals, to which the d-c calibrating voltages are applied. Connect the potentiometer to the volt box as shown in Fig. 6. Obtain balance and make a reading for each calibrating voltage. The voltage applied to the voltmeter is the potentiometer reading multiplied by the appropriate volt box factor.

12. CALIBRATION OF D-C AMMETERS

To use the potentiometer for calibrating d-c ammeters, it is necessary to connect an appropriate standard resistor or shunt in series with the ammeter. Apply the desired calibrating current values, using the potentiometer to measure this current as described in Section 9.

13. WATTMETER CALIBRATION

Fig. 8 illustrates the circuit arrangement required when using the potentiometer to calibrate or test wattmeters on direct current. For this application, the term "monitored quantity" in Fig. 8 represents the voltage to be held constant on the potential coils of the wattmeter during calibration. The term "measured quantity" in this figure refers to the current through the current coils of the wattmeter.

Connect the leads marked "monitored quantity" in Fig. 8 to the potentiometer binding posts on a volt box, the line binding posts of which are connected across the voltage applied to the wattmeter. Connect the leads marked "measured quantity" in Fig. 8 to the potential posts on a standard shunt, the current posts of which are connected in series with the current coils of the wattmeter.

Monitored and measured quantities may require the use of volt box and current shunt as when calibrating wattmeters.

Shaded areas indicate external guarding. This is recommended for special applications only, such as measuring high resistance unknowns. Note that guards are connected to binding post GD.

Fig. 8—Recommended connections for applications requiring stability checks of a non-measured quantity.

Select the K-3 potentiometer range as determined by the current range and standard shunt used. Then select a volt box setting or binding post connection and an emf setting on the AUX POT dial on the potentiometer. These settings must be such that the line voltage used equals the volt box factor multiplied by the auxiliary emf value used. Note that the auxiliary emf value is easily identified by considering that the numerals on the AUX POT dial represent millivolts when the K-3 potentiometer is on the .016 range; hundredths of a volt on the .16 range; and tenths of a volt on the 1.6 range.

To check or adjust the line voltage, simply turn the function switch to the AUX EMF position and tap the GALV SENS keys, while adjusting the line voltage, until no deflection occurs on the null indicator when key HIGH is tapped. The line voltage is equal to the auxiliary emf value multiplied by the volt box multiplier.

To make the current measurement, turn the function switch to the EMF position and use the potentiometer in the usual manner (Section 7) to measure the emf across the current shunt. Multiply the potentiometer reading by the reciprocal of the standard shunt resistance used.

IMPORTANT: For necessary corrections when using volt box and current shunt together, refer to Sections 8 and 9.

14. CALORIMETRY

The use of the auxiliary potentiometer in the circuit arrangement shown in Fig. 8 provides a convenient means of quickly checking the stability of d-c heater current during calorimetric experiments. For this application, the term "monitored quantity" represents heater current. The "measured quantity" is the thermocouple emf. (This emf represents the temperature difference between the measuring junction and the reference ice bath.)

Connect the leads marked "monitored quantity" in Fig. 8 to the potential posts on a suitable standard

current shunt, connected in series with the heater circuit. This shunt must be selected according to the heater current required and the potentiometer range to be used. The shunt resistance must be such that, when multiplied by the heater current desired, the resulting emf is one of the fifteen values available at the AUX EMF binding posts, preferably for the potentiometer range used. The numerals on the AUX POT dial represent millivolts when the main potentiometer is on the .016 range, hundredths of a volt on the .16 range and tenths of a volt on the 1.6 range.

To check and readjust heater current at any time during the experiment, turn the function switch to the AUX EMF position and tap the GALV SENS keys while adjusting the current flow, until no deflection occurs on the null indicator when key HIGH is tapped.

To follow the temperature rise in the calorimeter, turn the function switch to the EMF position and measure the thermocouple output on the K-3 potentiometer.

15. TEMPERATURE MEASUREMENTS USING RESISTANCE THERMOMETER

If a suitable value of current flow is maintained constant through a four-terminal resistance thermometer, the temperature can be followed by measuring the voltage drop across the thermometer with the potentiometer.

Using the arrangement shown in Fig. 8, connect the leads marked "monitored quantity" across a suitable standard resistor or current shunt connected in series with the resistance thermometer. Select a resistor value which, for the current required, will produce a voltage drop equal to one of the AUX POT values available, preferably on the K-3 potentiometer range used. Connect the leads marked "measured quantity" across the resistance thermometer terminals.

To establish the thermometer current and to check its stability periodically throughout a series of temperature changes, turn the function switch to the AUX EMF position and tap the GALV SENS keys while adjusting thermometer current, until no deflection occurs on a null indicator when key HIGH is tapped.

To measure temperature in terms of the voltage drop across the resistance thermometer, turn the function switch to the EMF position and measure the emf on the K-3 potentiometer.

16. HIGH IMPEDANCE EMF'S

As described in Section 3, the potentiometer is guarded against the adverse effect of excessive shunting of high impedance sources due to leakage paths from EMF+ to ground. It is usually desirable to extend this guarding from the potentiometer to the source by using an insulated guarded lead from the EMF+ binding post to the source, as shown in Fig. 3, part B.

The user who desires to measure very high impedance sources, such as electrochemical emf's, should note that the potentiometer shunts the emf source with 5,000 ohms or less if the null detector is connected across the galvanometer posts. (See Fig. 11.) For all such measurements it is desirable or necessary to eliminate this shunting of the source by the use of a high impedance null detector (preferably guarded) in the following manner. Insert the high impedance detector in series between the EMF+ terminal on the potentiometer and the + side of the emf source. The side

of the detector having highest resistance to ground must be connected to the emf source. This resistance to ground should be high in relation to the source impedance. If a guarded null detector is used, use a guarded lead from the source to the high impedance side of the detector and connect the guard conductor to potentiometer post GD. A guarded lead may also be used on the low impedance side of the detector which is connected to EMF+.

A d-c moving coil galvanometer may be connected to the potentiometer in the conventional manner for use during standardizing. It is recommended that the GALVANOMETER binding posts on the potentiometer be shorted out during the high impedance emf measurements.

PART IV

CALIBRATION CHECK AND MAINTENANCE

17. CHECKING PROCEDURE

The procedure described below provides an adequate check for those users desiring a means of determining, periodically, that the K-3 is performing satisfactorily. If the instrument does not meet the requirements specified, or if a more comprehensive check is essential, it is suggested that the instrument be returned to Leeds & Northrup Company. A procedure for certification of the 7553-5 or 7553-6, using an L&N 4393 Universal Ratio Set, is described in Directions 177151.

Although the following procedure is simple and well within the capabilities of the average user, this check should be made with utmost care under favorable conditions of temperature and humidity. The guarding precautions should not be necessary under these conditions. Make all settings and readings as precisely as possible.

(1) Connect a high quality, double pole, double throw switch (such as No. 3294 Pinch-Type Switch) between the standard cell and binding posts SC and EMF on the potentiometer, observing correct polarity so that the standard cell may be properly connected to either of these pairs of terminals by means of this switch. The same standard cell used to standardize the potentiometer is suitable for this purpose. Connect the working cells and the galvanometer in accordance with Section 4.

(2) Rotate the RANGE switch fully clockwise to the 1.6 (high) range. Leave the RANGE switch in this position throughout the check.

(3) Set the SC dial to the certified value of the standard cell being used. (Note the previous setting of this dial so that it may be returned to this point after the completion of the check.)

(4) Set the function switch on STD and position the external switch to connect the standard cell to the SC binding posts.

(5) Standardize the potentiometer as described in Section 5, obtaining a precise final balance in accordance with Section 7B.

(6) Set the function switch on EMF and position the external switch to connect the standard cell to the EMF binding posts.

(7) Make a measurement by following the general measuring procedure given in Section 7A. Knob A can be preset so that 1.0 appears in the window. Obtain a precise final balance in accordance with Section 7B.

(8) The final reading should not differ from the value set on the SC dial by more than two smallest divisions on the C dial scale.

(9) The potentiometer may be checked at any other voltage value appearing on the SC dial (1.0174 to 1.0205 volts), using the same standard cell. Set the SC dial to any value and repeat steps 4 to 8 inclusive.

(10) To check the slidewire travel of 100 main divisions (.01 volt) on the C dial scale, against one step on the B decade dial, set the SC dial to 1.0200 and adjust knobs A, B, and C to obtain a reading of exactly 1.0200. (The C

dial scale should be at the low end 00 value.)

(11) Set the function switch on EMF and position the external switch to connect the standard cell to the EMF binding posts.

(12) Adjust potentiometer current by means of the COARSE-MEDIUM and FINE dials to obtain a null balance on the detector.

(13) Rotate knob B one step counterclockwise to decrease the B dial digital figure from 2 to 1. Rotate knob C clockwise to obtain a null balance on the detector. The hairline should be within two smallest divisions of the 00 line separating the black and white portions of the scale.

18. MAINTENANCE

18A. Removal of 7553-5 from its Case

Turn each mounting screw (total of 6) two complete turns counterclockwise to release the clamping nut from the ledge inside the case. The mounting screws remain in place in the top plate. Lift the instrument from the case.

18B. Placing 7553-5 in its Case

Turn the clamping nut, on each mounting screw, so that it will clear the ledge inside the case when the top plate is fitted into place on the case. After the instrument is positioned in the case, turn each mounting screw counterclockwise until a click is heard and then turn each screw clockwise until it is tight.

18C. Removal of Cover from 7553-6

This can be done while the instrument is mounted on the rack or panel as well as when not mounted. To do this, turn each of the four (4) cover fasteners, Fig. 12, counterclockwise approximately 1/4 turn and lift off the cover. The fasteners remain with the cover.

18D. Placing Cover on 7553-6

Turn each of the four (4) cover fasteners so that the slot in each fastener will fit over its holding wire (attached to the inside of the case) when the cover is fitted in place on the case. After the cover is fitted in place on the case, turn each fastener clockwise approximately 1/4 turn to tighten the fasteners on their holding wires.

18E. Removal of 7553-6 from its Case

The instrument must be removed from the rack or panel to permit removal from the case. Then remove the two (2) screws from each handle to remove the handles and release the instrument from the case. Then lift the instrument from the case.

18F. Placing 7553-6 in its Case

Fit the instrument in the case. Hold each handle in place on the top plate and insert the two screws in each handle, from the underside of the case flange, and tighten these screws to hold the handles and top plate in place.

18G. Cleaning

(1) Slidewires

Clean and lubricate the slidewire windings only with an approved cleaner-lubricant which can be obtained from Leeds & Northrup Company by ordering Part Number 124179. Do not clean the slidewire with any other lubricant or with an abrasive material.

(2) Binding Posts

The guarded binding posts are insulated by Acrylonitrile Styrene Copolymer. If they become contaminated, the surface film may provide leakage paths to the case. Although not necessary under normal usage, this material may be cleaned with a dilute solution of detergent and water. Chlorothene may be used in place of the detergent and water.

(3) General

The vinyl finish on this instrument has considerable resistance to chipping and scratching. If necessary, the instrument case may be cleaned with a soft cloth dampened with water containing a small amount of a mild detergent.

The readout window and instrument panel may be cleaned in the same manner.

18H. Replacing Contact Assembly of Slidewire C

The gold alloy slidewire contacts may gradually wear down with continued use and the contact assembly might eventually have to be replaced. To do this, remove the assembly from the end of the arm by removing the four screws; then mount the new assembly on the arm in the same manner. The contact pressure must be two to three ounces. IMPORTANT: The zero adjustment described in Section 6 must be made after the slidewire contact assembly is replaced.

18J. Mechanical Adjustments

If necessary, the amount of slack in the belt driven by knob C' may be adjusted to obtain smooth control of the slidewire by knob C as well as by knob C'. The belt slack is varied by rotating an eccentric bushing on the shaft of knob C'. Remove the instrument from its case and rest it face down on the handles. Loosen the setscrew in the C' knob and retighten it near the end of its shaft to expose the flats on the eccentric bushing. Loosen the 7/8" hex nut on the eccentric bushing (on the under side of the panel) and retighten so that it is just "snug". If the belt is too slack knob C' will slip. When too tight the action of knob C is not smooth. Using a 3/8" wrench (on the face side of the panel), rotate the eccentric bushing to tighten the belt. Then back off to increase the slack until the irregular action of knob C just disappears. Tighten the 7/8" hex nut. When the belt is properly adjusted, the torque near the end of the slidewire contact arm is 10 to 20 ounce-inches.

If the digits or decimal point reading device do not line up properly, they may be readjusted as follows. The rectangular plates which extend out from under the three switches RANGE, A, and B on the sub-panel, serve as adjusting levers to shift the digits up or down in the reading window. First loosen the clamp nut on the switch shaft under the sub-panel. Then loosen the plate screw in the switch corresponding to the digit out of line and shift the lever slightly to correct this condition. Tighten these nuts securely when the adjustment is completed.

18K. Replacement Parts List

The list of parts on the following page includes a number of items identified by an asterisk which we suggest be carried in a spare parts stock. Repairs involving parts not listed should normally be made by Leeds & Northrup Company.

DESCRIPTION	PART NUMBER
Reading Window	066107
*Head (Binding Post)	Std. 19-A
*Connector Link	074057
*Knobs (RANGE, A, B, and C)	2-4-9-7
Knob (C')	2-1-9-4
Key Assembly (LOW, MED)	031166
Key Assembly (HIGH)	031166 (mod.)
Key Assembly (REV)	031165
* Head for above key assemblies	Std. 131
Washer for above key assemblies	Std. 3257-J
*Plug Screw Cap for Zero Adjustment	Std. 3091-AB
Screw Assembly (Top Plate Mounting):	
Screw	4-4-1-24
Bushing	006568
Spring, upper	28-1-3-10
Spring, lower	28-1-3-9
Clamp	72-4-1-1
Retaining Ring	27-3-3-12
*Belt for driving Slidewire C	074063
*Contact Assembly (Slidewire C)	R-30815-T
Handle	046044
Lid, metal (optional)	039375
Dust Cover	095036
Box	039374
Slidewire Cleaner-Lubricant (2 oz with cloth wipers)	124179
Brackets for table mounting of K-3	127272

*Suggested spare parts.

PART V

CIRCUIT PRINCIPLES

The potentiometer circuit is shown in simplified schematic form in Fig. 2. This schematic is arranged to show clearly the electrical relationships between basic parts of the circuit. These are, essentially; the two main branches of the basic divided circuit potentiometer, the compensated Ayrton shunt range changing network, and the galvanometer sensitivity and damping circuit.

The dot appearing over the final digit of some current values in Figs. 9 and 10 identifies the repetend of an interminable recurring decimal. This final digit should be repeated indefinitely to obtain the theoretically correct value.

19. THE BASIC POTENTIOMETER

The network of the basic potentiometer is shown in Fig. 9. This drawing illustrates the method used to establish the potential E_X, which is compared to the unknown.

As illustrated in Fig. 9, two voltages are established in the right branch; E_B, determined by the position of the B decade contact, and E_C, determined by the position of the slider on the C slidewire. The opposing voltages, E_A and $(E_B + E_C)$ are adjusted to establish a voltage E_X, which is equal in magnitude to the unknown emf.

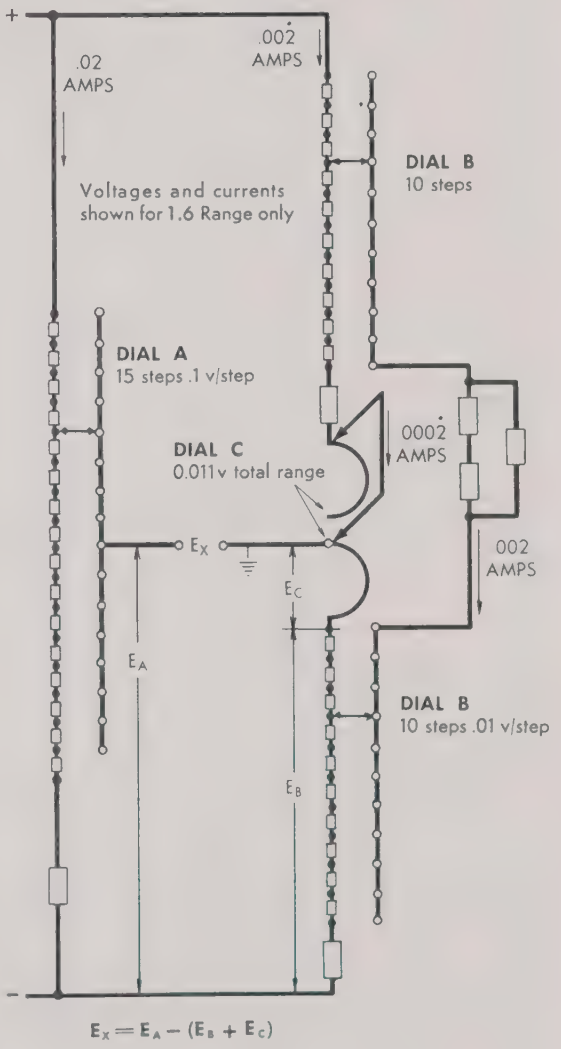
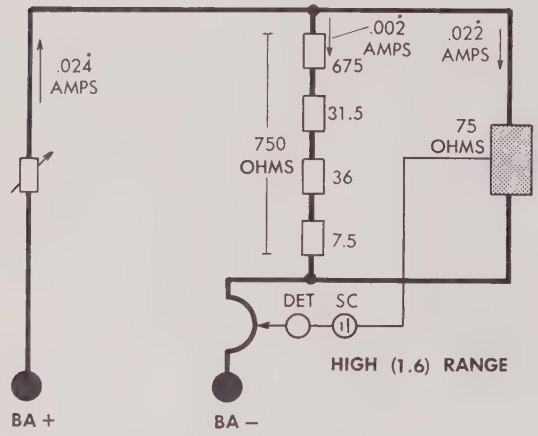
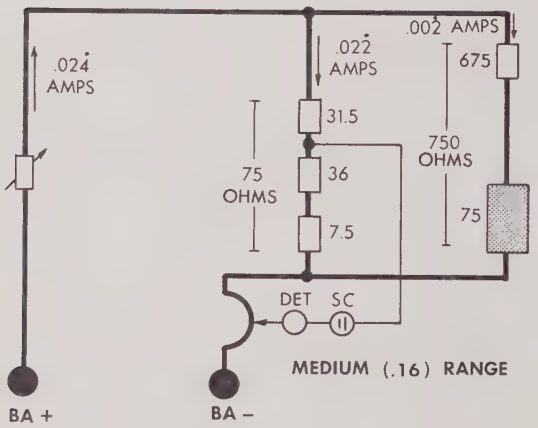


Fig. 9—7553-5 or 7553-6 Potentiometer basic circuit with range selecting branch and null detector circuits omitted. Ex is adjusted to balance against unknown emf.

20. THE RANGE CHANGING NETWORK

The three potentiometer ranges are obtained by changing the total current flow through the main potentiometer network shown in Fig. 9. The actual range changing circuit is shown in the full schematic, Fig. 2. The three drawings shown in Fig. 10





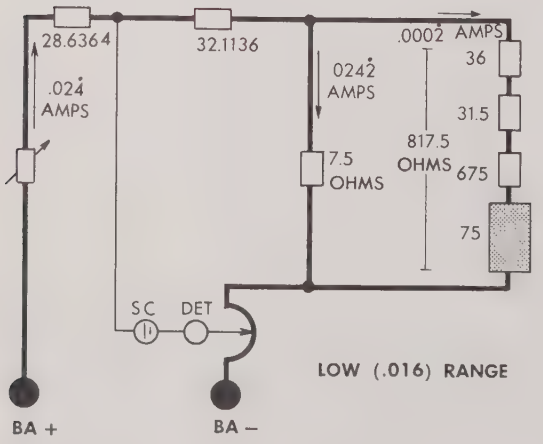


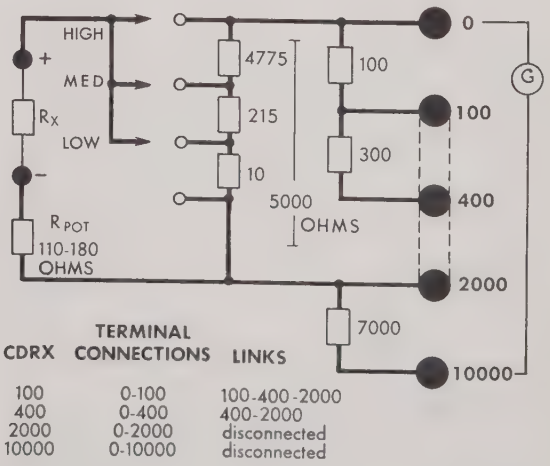
Fig. 10—7553-5 or 7553-6 Potentiometer simplified circuits illustrating the compensated Ayrton Shunt type range selection. Portion of circuit in shaded area is shown in Fig.9.

represent the entire potentiometer circuit as it exists for each position of the RANGE switch. The potentiometer network of Fig. 9 is represented by a shaded block.

Note in Fig. 10 that, when changing range, the current through the main potentiometer network is changed by factors of ten while the total potentiometer current is maintained constant for all ranges. These figures also illustrate the manner by which standardizing is made possible on each range.

21. SENSITIVITY AND DAMPING CIRCUITS

The damping and sensitivity resistor arrangement is shown in Fig. 11. The sensitivity keys control a 5000-ohm Ayrton shunt providing sensitivity ratios of 1, 1/20, and 1/400, the actual value depending upon the resistance of the unknown and the damping resistance used. Galvanometer damping is controlled by resistors placed either in series or in



CDRX	TERMINAL CONNECTIONS	LINKS
100	0-100	100-400-2000
400	0-400	400-2000
2000	0-2000	disconnected
10000	0-10000	disconnected

Fig. 11—7553-5 or 7553-6 Potentiometer galvanometer sensitivity and damping arrangements.

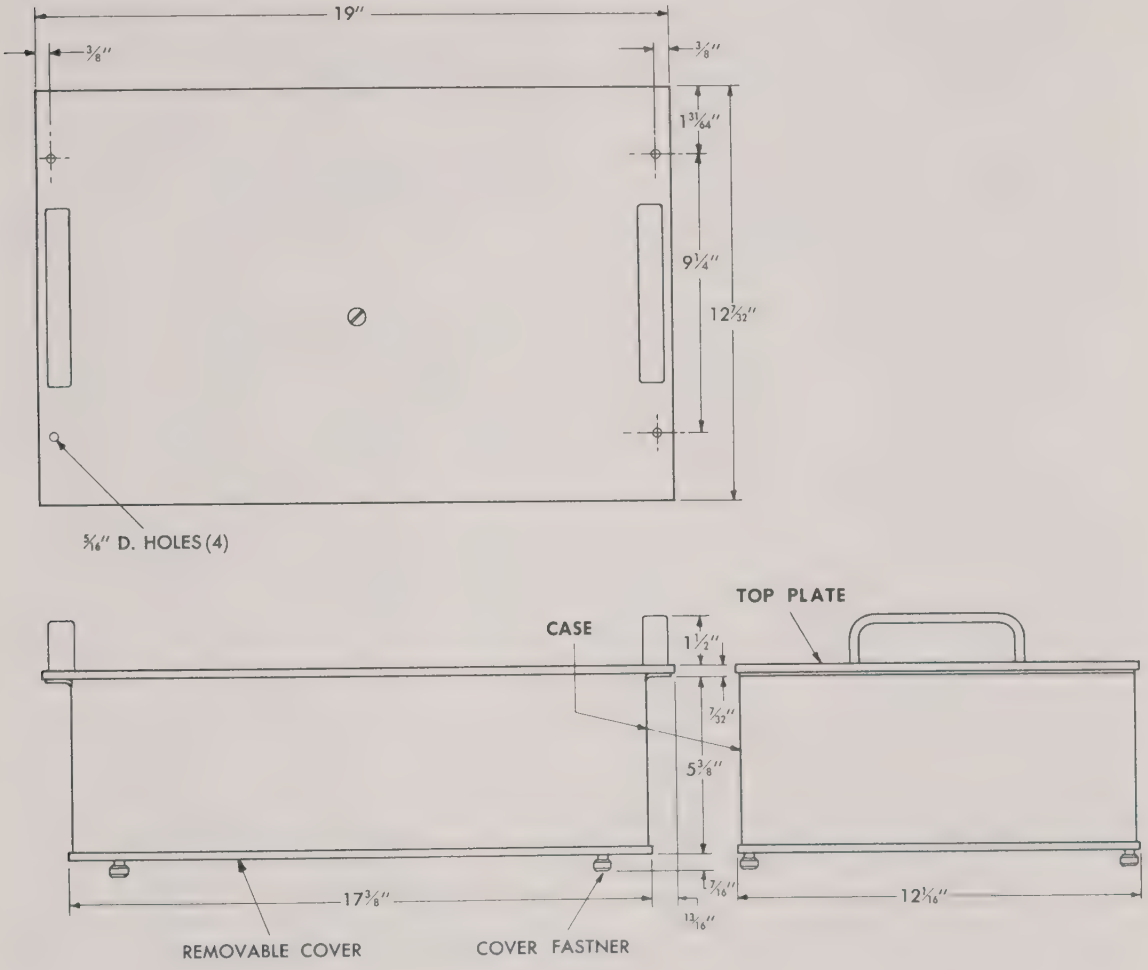


Fig. 12—7553-6 Potentiometer, outline and mounting dimensions.

parallel with the sensitivity Ayrton shunt. The nominal values indicated at the binding posts are approximations based on either the series or parallel combination of the damping resistance, Ayrton shunt, potentiometer resistance, and the resistance of the unknown emf.

APPENDIX

SIMPLIFIED CALIBRATION CHECKS

The following checks are made using only the 7553 Potentiometer under test with a standard cell, battery and detector.

1. Check main dials against standard cell dial (after standardizing current) by connecting the standard cell to the EMF terminals. Check all points on standard cell dial against the main dials as described in Section 17, Steps (1) to (9).

2. Check the C dial (100 main divisions) against one step on the B dial at the 1.02 volt position as described in Section 17, Steps (10) to (13).

3. Test reduction factors as follows:

(a) Standardize on X1 Range and read standard cell dial.

(b) Move range dial to X.1 Range. Rebalance if necessary by moving position of the standard cell dial—note reading.

(c) Move range dial to X.01, rebalance if necessary—note reading of standard cell dial.

The above three tests may be included as part of the basic URS calibration data. Readings obtained above can then be compared to corresponding data of URS calibration. Normally the readings should be alike within approximately 0.005%.

4. Check the total of the B dial against the first 5Ω resistor of the AUX POT dial in the following manner.

(a) Plate function switch on EMF position and AUX POT dial on zero. Connect Galvanometer to AUX EMF+ and EMF− terminals.

(b) With B dial on X, the C dial should read zero.

(c) With B dial on 9, the C dial should read 100.0.

The following tests require a second 7553 Potentiometer, or equivalent, although a precisely calibrated instrument is not necessary. The voltage of each step on the A dial is measured and compared to the first 5Ω resistor of the AUX POT dial. The first 10 steps of the A dial may be summarized and corrected to the value of the 1.0 volt reading obtained in the check against the standard cell. (See check 1 above.) A calculation of the summation value for each step will provide an accurate calibration of the first dial. Proceed as follows:

1. Set function switch to EMF. Connect EMF− of second potentiometer to EMF+ of potentiometer under test, and EMF+ of second potentiometer to GD of potentiometer under test.

2. With AUX POT and A dials on zero, the second potentiometer should balance near 0.100000 volt.

3. Move both the AUX POT dial and the A dial to the No. 1 position. The second potentiometer should again balance near 0.100000 volt.

4. Continue the above through fifteen steps, moving each dial to successively higher and correspondingly numbered positions.

5. Check the total of the B dial against the first 5Ω resistor by moving EMF+ connection of second potentiometer to EMF– of potentiometer being tested. With B dial on X, and C dial on 100, the second potentiometer should read near 0.000000 volt. With B dial on 9 and C dial on 100, the potentiometer should again read near 0.000000 volt.

6. Additional comparison checks such as a build-up of each step of the B dial as compared to the change from 0 to 100 of the C dial, or checking each step of the B dial against each A dial step of the second potentiometer used on X.1 Range etc., may be taken by bucking output emf's of the two potentiometers.

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